Space Weather Technical Forecast

Issued on Thursday, 29 December 2022 at 12:55 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of Minor Geomagnetic Storms later Day 1 into Day 2 (29-30 Dec). Chance of M-class flares throughout. Chance of Active electron fluence.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity has been Moderate over the past 24 hours with a long period M1 flare originating from over the NE limb, peaking at 29/0729 UTC. There are now nine sunspot groups on the disc, with three new regions developing over the period. AR3169 in the northwest has shown activity during its transit across the disc, but is now rotating off the disc and is difficult to see clearly. AR3176 and AR3177 are the two largest regions on the disc, but neither are showing much complexity at present. All other regions appear to be small and simple.
No Earth directed CMES were observed in available imagery during the period.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by DSCOVR and ACE at L1, showed a waning High Speed Stream (HSS), likely from CH57/+. Wind speed was at slightly elevated levels throughout, easing slightly from around 460 km/s to near 420 km/s. The density was at average or below average levels. The IMF, Bt, has been weak at 7nT or below. The north-south component, Bz, fluctuated weakly between +5/-6nT. The phi angle was mostly positive (away from the Sun). The resulting geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2MeV) as recorded at GOES16, was generally at moderate levels, but temporarily peaked into High levels, with a maximum of 1210 pfu at 29/1140 UTC. The 24-hour integrated electron fluence followed a slight rising trend, recording 5.69e7 integrated pfu at 29/0001UTC.

Four-Day Space Weather Forecast Summary
Solar Activity: Solar activity is expected to be Low with a chance of isolated M-class flares. Although AR3169 is expected to depart the Earth-facing disc through the next couple of days, this is likely to be counteracted by arrivals across the eastern limb.

Solar Wind / Geomagnetic Activity: A CME may give a glancing blow at Earth on 29th December, although this is low confidence. Solar wind speeds are currently slightly elevated. A high speed stream from CH59/+ is expected to arrive either later on Day 1 (29 Dec) or early on Day 2 (30 Dec). Elevated, or potentially Strong, solar wind speeds are then likely to persist through much of the period, before gradually declining on Day 4 (01 Jan).
Geomagnetic activity is expected to be largely Quiet to Unsettled at first, becoming Unsettled to Active later on Day 1 into Day 2, with a chance of G1/Minor Storm intervals. This is due to the onset of CH59/+, perhaps coupled with the above CME. Geomagnetic activity and the risk of G1 should reduce through Days 3 and 4 (31 Dec - 01 Jan), as the HSS influence slowly eases.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, with a daily Slight Chance of reaching S1 levels.

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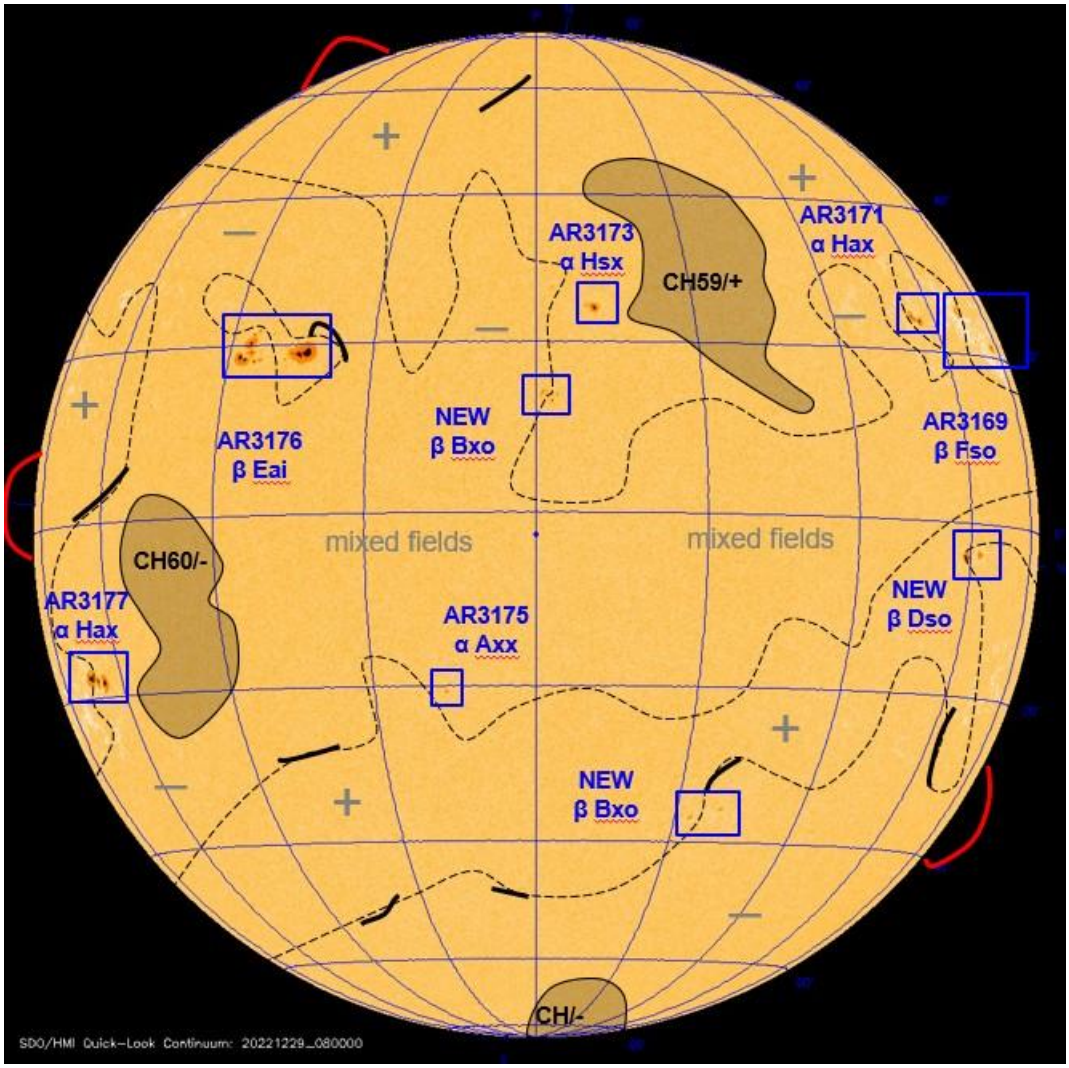
High energy electron flux (greater than 2MeV) at GOES16 is currently at Moderate to High levels. The HSS arrival and possible CME glancing blow through the next 24 hours mean that flux levels are likely to be suppressed in the short term. A recovery in flux values is likely from Day 3 (31 Dec). Corresponding fluence levels may exceed the Active threshold during Day 1 (29 Dec), but a drop is then considered likely into Day 2 (30 Dec), before a possible increase from Day 3 (31 Dec).

Figure 1. Solar Analysis Valid 29/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME that left the Sun on the 25th December should pass near Earth on 29th December, perhaps giving a glancing blow. This is low confidence however, with the CME assessed as mainly south and ahead of the Sun-Earth line. No other obviously Earth directed CMEs feature in the forecast.

Solar wind speeds are currently slightly elevated. A high speed stream from CH59/+ is expected to arrive either later on Day 1 (29 Dec) or early on Day 2 (30 Dec). Elevated, or potentially Strong, solar wind speeds are then likely to persist through much of the period, before gradually declining on Day 4 (01 Jan). This is based on empirical techniques, as CH59/+ is much changed from the previous rotation and thus recurrence is not providing good guidance. MOSWOC Enlil suggests a wind enhancement starting through Day 2. This is considered to be a little late given the shape and position of CH59/+ on the disc. STEREO-A is currently around a day upwind of Earth in sampling the solar wind and is showing elevated to strong solar wind spends arriving around 24 hours ago, although admittedly with limited data points.

Geomagnetic activity is expected to be largely Quiet to Unsettled at first, becoming Unsettled to Active later on Day 1 into Day 2, with a chance of G1/Minor Storm intervals. This is due to the onset of CH59/+, perhaps coupled with the above CME. Geomagnetic activity and the risk of G1 should reduce through Days 3 and 4 (31 Dec - 01 Jan), as the HSS influence slowly eases.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	50	40	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
25/1245	Partial	AR3169	NW quadrant	520 km/s	Later 29th December	Low confidence

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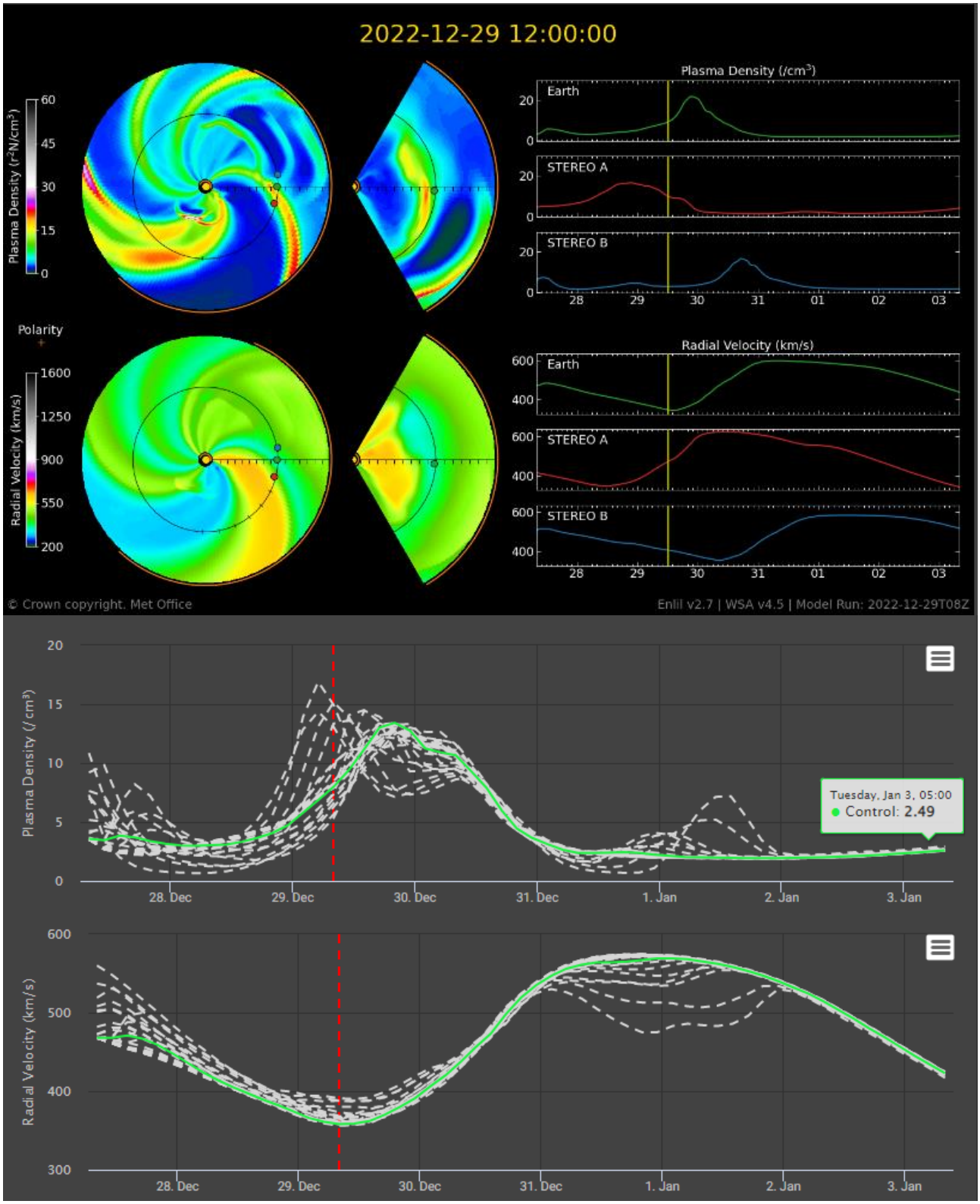
Figure 2: MOSWOC Enlil and ensemble, showing a possible CME arrival on 29 Dec, with a HSS arrival through 30 Dec. The HSS arrival may be a little late in Enlil.



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Radio Blackouts - X-Ray Flares:

There are currently nine sunspot regions on the visible disc, and activity is currently Moderate, with a long period M1 flare from over the NE limb, peaking at 29/0729 UTC. AR3169 (Fso/Beta) has shown some activity during its transit across the disc, but is now in the process of rotating off the northwest limb and is becoming difficult to see clearly. Its classification is likely to be maintained as it rotates off. AR3176 (Eai/Beta) in the northeast is the largest region on the disc, but is reasonably straightforward magnetically. The next largest region in the southeast is AR3177 (Hax/Alpha), but this now appears to be unipolar with no obvious trailing spots. All other regions appear relatively small and simple at the present time, although there are three recently developed regions, one of which is still developing, which will bear watching.

Solar activity is expected to be Low to Moderate, with a daily Chance of further M-class activity through the period. Although some regions are rotating off, far side seismographs and STEREO-A EUV imagery suggest further regions to rotate on. This means that flare probabilities have been kept flat through the four days, although any new regions cannot be assessed for flare risk until they appear on the facing disc for analysis.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is currently at Background levels, and is expected to remain generally unchanged through the period.

There remains a slight chance of a proton event reaching the S1 level throughout the period. Although AR3169 is rotating off the disc, the risk of a proton event from this region will remain until it is well over the limb, at which point AR3176 will be in the western hemisphere with an increasing risk from this region.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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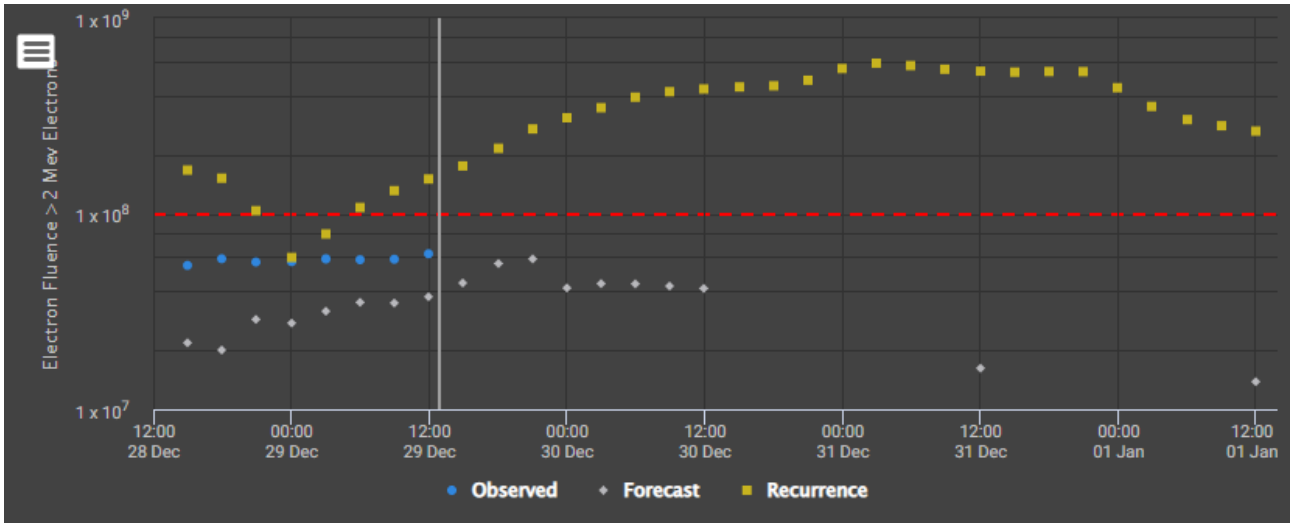
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) at GOES16 is currently at Moderate to High levels, with the peak today above the High threshold. However, with a possible glancing blow from the 25 December CME and the arrival of a HSS from CH59/+ expected through the next 24 hours, flux levels are likely to be suppressed once again in the short term. A recovery in flux values is likely from Day 3 (31 Dec), but will be dependent on the strength of the HSS and its impact on the radiation belts.

Corresponding fluence levels may exceed the Active threshold during Day 1 (29 Dec), but a drop is then considered likely into Day 2 (30 Dec) with the possible CME and HSS arrivals. Recharging and recovery of the radiation belts is expected towards the end of the period, at which point the chance of crossing the Active threshold increases once again. The changes in the shape and position of the upcoming coronal hole compared to the last rotation means that persistence forecasting is very little use. MOSWOC REFM is forecasting a decline in the short term, which is reasonable, although it may be right for the wrong reasons, with an increase likely later Day 3.

GEO Electron Environment	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	30	20	10	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 3: MOSWOC REFM showing a declining trend in the coming days which may be right for the wrong reasons, with an increase likely later Day 3.



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